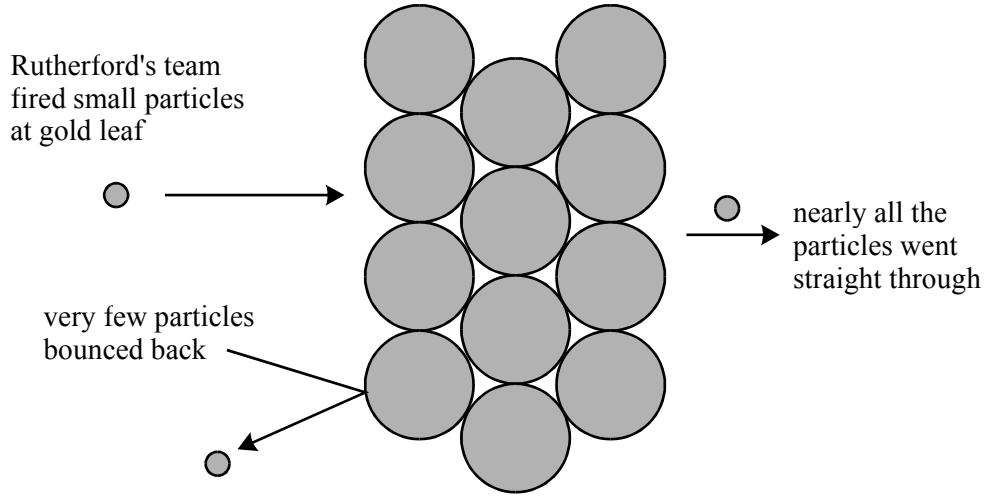
1.



Scientists thought that all the parts in atoms were evenly spread.

(a) What did scientists expect to happen in this experiment?

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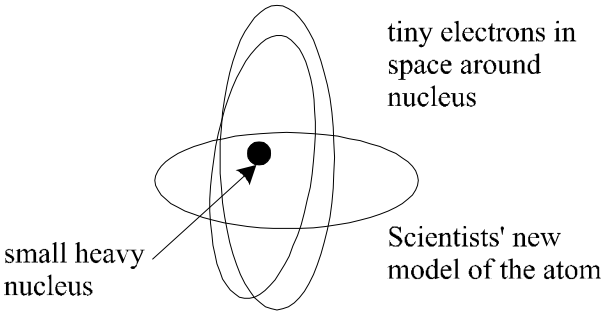
(2)

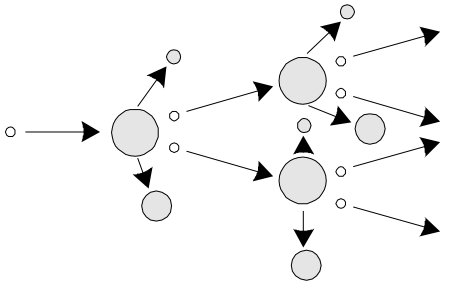
(b) Complete the sentence.

The experiment showed that atoms must be mostly empty .....



(1)
(Total 3 marks)

2. The diagram represents the process called nuclear fission.



(a) What do each of the following parts of the diagram represent?

○ = ...

● = ...

○ and ● = ...

(3)

(b) Once the fission process has been started, it continues by itself. Explain why.

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(2)

(c) Many thousands of times more energy is released from 1g of nuclear fuel than from burning 1g of fossil fuel.

Explain, in as much detail as you can, why this is so.

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(2)
(Total 7 marks)

3. (a) When an atom of thorium-232 decays, an alpha (α) particle is emitted from the nucleus. An atom of radium is left behind.

An alpha particle consists of two protons and two neutrons.

We can represent this radioactive decay in a special kind of equation:

$$^{232}_{90}\text{Th} \longrightarrow {}^{4}_{2}\alpha + {}^{228}_{88}\text{Ra}$$

^{228} ◄- - - number of nucleons (protons + neutrons)

^{88} ◄- - - number of protons

Thorium-228 is also radioactive.

Atoms of this isotope also decay by emitting an alpha particle and producing an isotope of radium.

Complete the equation for this decay.

$$^{232}_{90}\text{Th} \longrightarrow$$

(4)

(b) An atom of radium-228 decays by emitting a beta (β) particle from the nucleus.

A beta particle is in fact an electron (symbol $^{0}_{-1}\text{e}$).

The effect of this is to change a neutron into a proton.

An atom of actinium remains.

This type of decay can also be represented by an equation:

$$^{228}_{88}\text{Ra} \longrightarrow {}^{0}_{-1}\text{e} + {}^{228}_{89}\text{Ac}$$

^{228} ◄- - - number of nucleons (protons + neutrons)

^{89} ◄- - - number of protons

This isotope of actinium is radioactive.

An atom of actinium-228 also decays by emitting a beta particle.

An isotope of thorium is left behind.

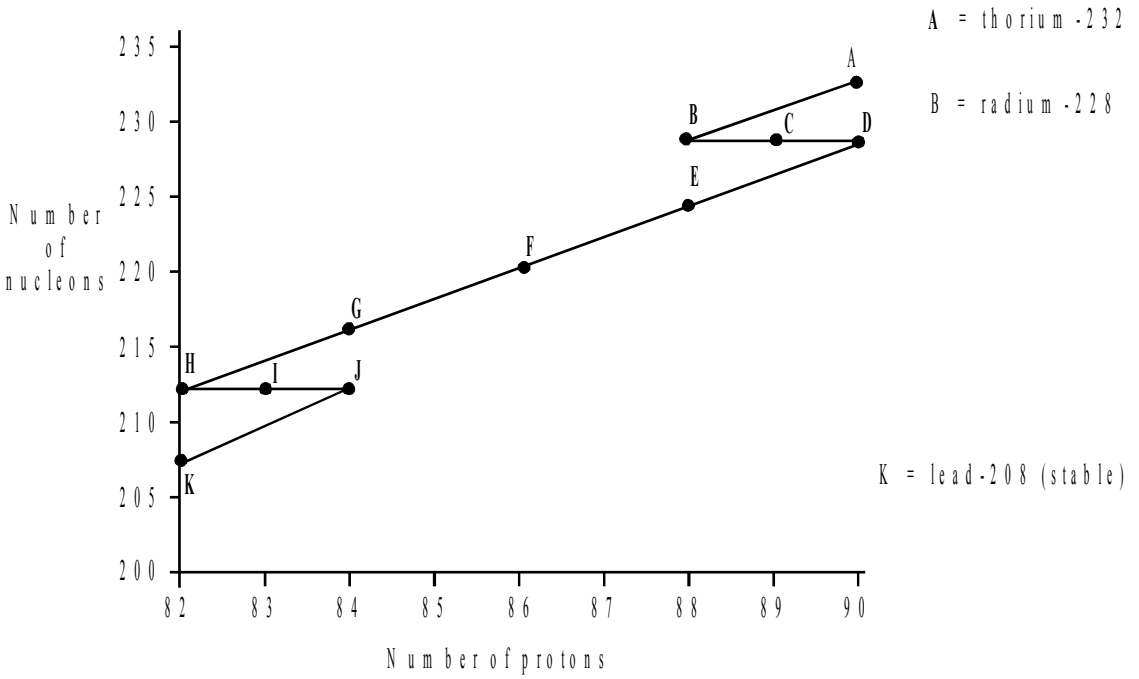
Complete the equation for this decay.

$$^{228}_{89}\text{Ac} \longrightarrow$$

(4)

(c) Thorium-232 eventually decays to the stable isotope lead-208.

All the steps in this process can be shown on a diagram.



(i) Complete the sentences:

During the decay from (A) to (B) a ..... particle is emitted.

During the decay from (B) to (C) a ..... particle is emitted.

During the decay from (E) to (F) a ..... particle is emitted.

During the decay from (I) to (J) a ..... particle is emitted.

(2)

(ii) The table shows how long it takes for half of the atoms of each isotope to decay.

ISOTOPE	TIME FOR HALF TO DECAY
A	billions of years
B	7 years
C	6 years
D	2 years
E	4 days
F	1 minute
G	0.4 seconds
H	10 hours
I	1 hour
J	0.3 microseconds

A rock sample contains:

- many atoms of thorium-232
- even more atoms of lead-208
- hardly any atoms of any of the other isotopes shown on the diagram

Explain this as fully as you can.

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(3)
(Total 13 marks)

4. (a) (i) Describe the structure of alpha particles.

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.....

(2)

(ii) What are beta particles?

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.....

(1)

(b) Describe how beta radiation is produced by a radioactive isotope.

.....

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(1)
(Total 4 marks)

5. The first commercial nuclear power station in the world was built at Calder Hall in Cumbria.

(a) The fuel used at the Calder Hall power station is uranium. Natural uranium consists mainly of two isotopes: uranium-235($^{235}_{92}U$) and uranium-238($^{238}_{92}U$). The nucleus of a uranium-235 atom is different to that of a uranium-238 atom.

(i) Where is the nucleus in an atom?

.....

(1)

(ii) Name the **two** types of particle found in the nucleus.

..... and .....

(2)

(iii) How is the nucleus of a uranium-238 atom different to the nucleus of a uranium-235 atom?

.....

....

....

(2)

(b) In the nuclear reactor fission of uranium atoms takes place in reactions such as the one shown below.

$$^{235}_{92}\mathrm{U} \quad + \quad ^{1}_{0}\mathrm{n} \longrightarrow \quad ^{138}_{53}\mathrm{I} \quad + \quad ^{95}_{39}\mathrm{Y} \quad + \quad 3(^{1}_{0}\mathrm{n})$$

The nuclear reactions are carefully controlled in the power station so that a chain reaction takes place.

Explain, as fully as you can:

(i) how fission of uranium atoms takes place in a nuclear reactor;

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(ii) how this leads to a chain reaction;

.....

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.....

(iii) why it can be used to generate electricity.

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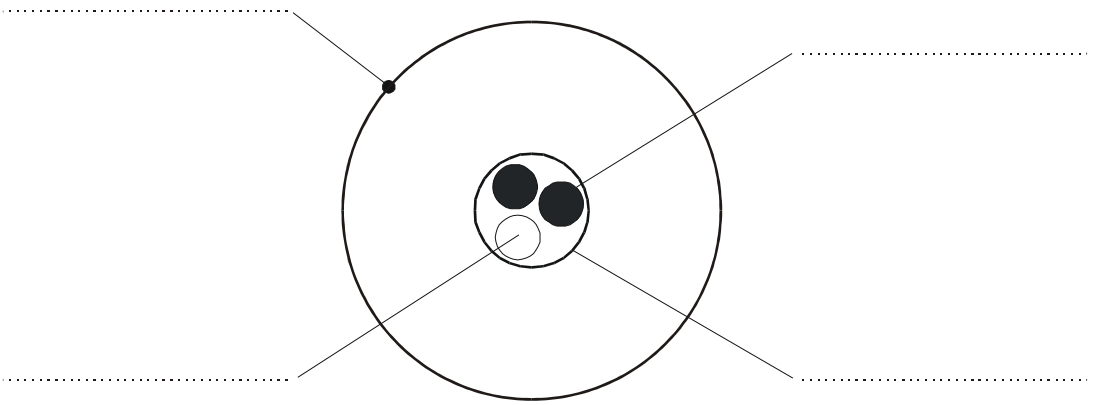
(4)
(Total 9 marks)

6. (a) Tritium (${}^{3}_{1}H$) is an isotope of hydrogen. Tritium has a proton number of 1 and a mass number of 3.

(i) The diagram below shows a simple model of a tritium atom. Complete the diagram by adding the names of the particles indicated by the labels.



(4)

(ii) Explain how the nucleus of an ordinary hydrogen atom is different from the nucleus of a tritium atom. Ordinary hydrogen atoms (${}^{1}_{1}H$) have a mass number of 1.

.....

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.....

(2)

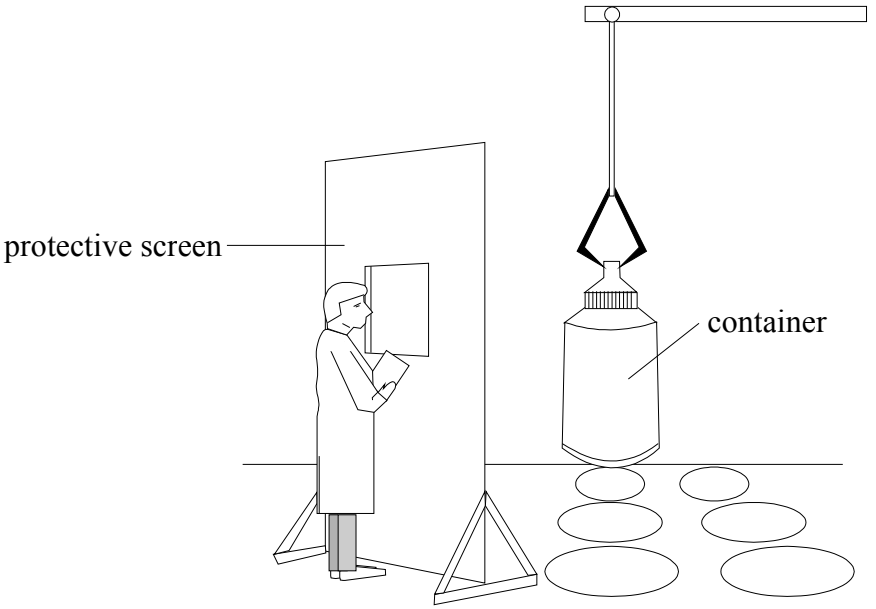
(iii) Tritium is a radioactive substance which emits beta (b) radiation.
Why do the atoms of some substances give out radiation?

.....

.....

(2)

(b) Tritium is one of the elements found in the waste material of the nuclear power industry. The diagram below shows a worker behind a protective screen. The container holds a mixture of different waste materials which emit alpha (a), beta (b) and gamma (g) radiation.



Suggest a suitable material for the protective screen. The material should prevent radiation from the container reaching the worker. Explain your answer.

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(2)
(Total 10 marks)

7. Nuclear fusion in the Sun releases large amounts of energy.

(i) Explain what is meant by nuclear fusion.

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(3)

(ii) Why is energy released by such nuclear fusion reactions?

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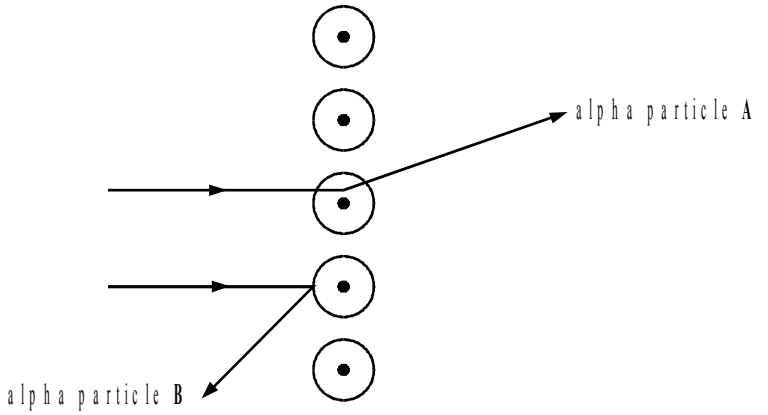
(2)
(Total 5 marks)

8. The diagram below shows the paths of two alpha particles A and B into and out of a thin piece of metal foil.



(a) The paths of the alpha particles depend on the forces on them in the metal.
Describe the model of the atom which is used to explain the paths of alpha particles aimed at thin sheets of metal foil.

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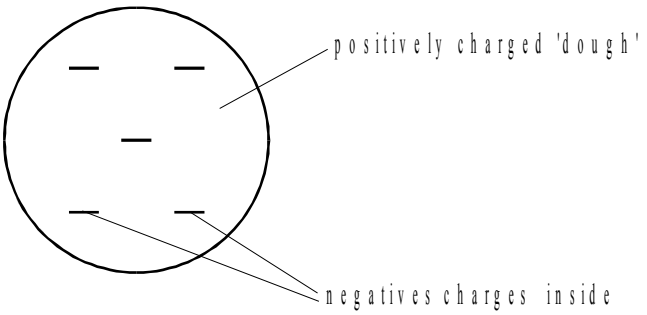
(3)

(b) Scientists used to believe that atoms were made up of negative charges embedded in a positive 'dough'. This is called the 'plum pudding' model of the atom.
The diagram below shows a model of such an atom.


positively charged 'dough'
negatives charges inside

(i) Explain how the 'plum pudding' model of the atom can explain why alpha particle **A** is deflected through a very small angle.

.....

.....

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(2)

(ii) Explain why the 'plum pudding' model of the atom can not explain the large deflection of alpha particle **B**.

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(3)

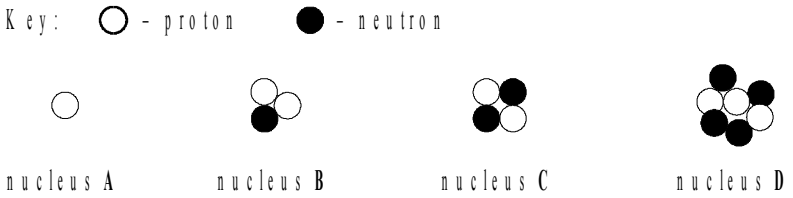
(c) We now believe that atoms are made up of three types of particles called protons, neutrons and electrons.

Complete the table below to show the relative mass and charge of a neutron and an electron. The relative mass and charge of a proton have already been done for you.

PARTICLE	RELATIVE MASS	RELATIVE CHARGE
proton	1	+1
neutron		
electron		

(2)

(d) The diagrams below show the nuclei of four different atoms **A**, **B**, **C** and **D**.



(i) State the mass number of C. .....

(ii) Which two are isotopes of the same element? ..... and .....

Explain your answer.

.....

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.....

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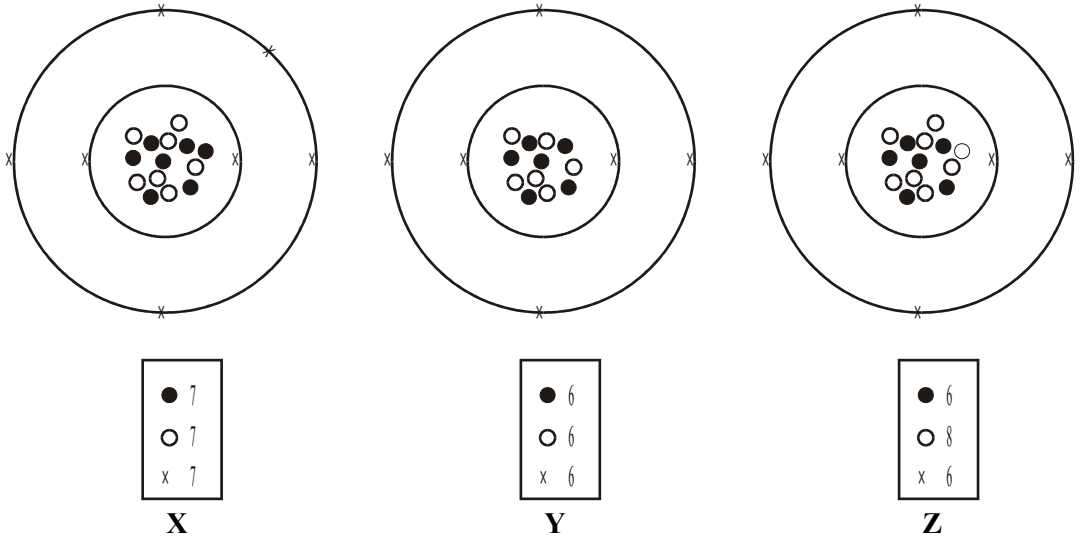
(4)
(Total 14 marks)

9. (a) The diagrams represent three atoms **X**, **Y** and **Z**.



X **Y** **Z**

Which **two** of the atoms are from the same element?

.....

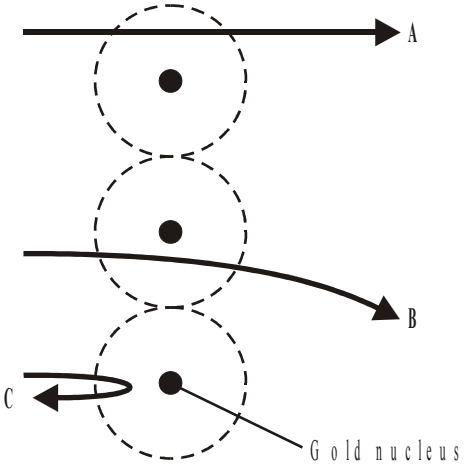
Give a reason for your answer.

.....

.....

(2)

(b) In the early part of the 20th century some scientists investigated the paths taken by positively charged alpha particles into and out of a very thin piece of gold foil. The diagram shows the paths of three alpha particles.



Explain the different paths **A**, **B** and **C** of the alpha particles.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

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(3)
(Total 5 marks)